Associating Particle Fate with the Operation of In-Delta Storage Islands

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Introduction

The California Department of Water Resources Integrated Storage Investgations (ISI) group linked DWR's statewide water operations model (CALSIM) with its Delta hydrodynamics and water quality model (DSM2) in order to evaluate the changes in Delta water quality due to releasing water from the two proposed In-Delta Storage (IDS) reservoir islands, Bacon Island and Webb Tract (Figure 1). The goal of the IDS project is to use the two islands as storage facilities to increase drinking water supply while maintaining environmental standards. In order to meet this goal, it was necessary for CALSIM and DSM2 to be used in an iterative process, where CALSIM output was used to run DSM2, and then relationships developed based on the DSM2 results were used as constraints in new CALSIM simulations.

This poster focuses on the development of the particle fate - flow based relationships generated by the DSM2 Particle Tracking Model (PTM). Particles tracked by PTM are a surrogate for dissolved organic carbon (DOC) released from the islands. PTM simulates the movement of neutrally buoyant particles in a psuedo 3-D environment by converting 1-D flow and stage (i.e. water level) information provided by DSM2-HYDRO to 3-D based on observed channel velocity profiles. PTM accounts for particle dispersion due to channel bathymetry and particle diffusion due to natural turbulence in the flow.

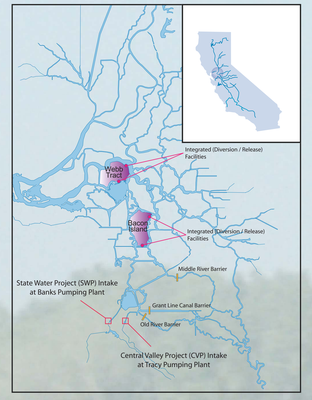


Figure 1: Sacramento-San Joaquin Delta and proposed In-Delta Storage project islands.

Methodology

The iterative process used in the ISI-IDS modeling investigations is shown below in Figure 2. Output from one model (step) was used as input for the next model (next step in the process). Though the focus of the ISI-IDS modeling efforts was the project yield (i.e. amount of additional water provided by the two islands) and the changes in urban drinking water quality associated with releases from the islands, these final results required understanding the physical impact releasing water from Bacon Island and Webb Tract would have on the Delta. The focus of this poster is on the development of particle fate-flow based relationships from step 3 and step 4 (highlighted in red) of the ISI-IDS modeling process.

Operations Summary:

- 73 years of statewide monthly and 16 years of statewide daily operations simulated;
- 2020 level of development (water demands);
- Project island diversion and release schedules accounted for evaporation and seepage; and
- Salinity objectives met using an Artificial Neural Network.

Hydrodynamic Summary:

- 16 years simulated, representing a variety of water year classifications;
- 3 permanent South Delta agricultural barriers and the fish protection barrier were operated as currently proposed by DWR Bay-Delta Office;
- Water released from islands in late Spring and mid Summer (13 release periods in 16-year study); and
- State Water Project and Central Valley Project exports were increased to match island releases.

Particle Tracking Summary:

- Releases from Webb Tract and Bacon Island simulated separately;
- 2 integrated facilities (release points) per island;
- 250 particles released at each integrated facility;
- Particles injected uniformly over 24-hour period;
- Particle movement tracked for 31 days; and
- 13 release periods simulated.

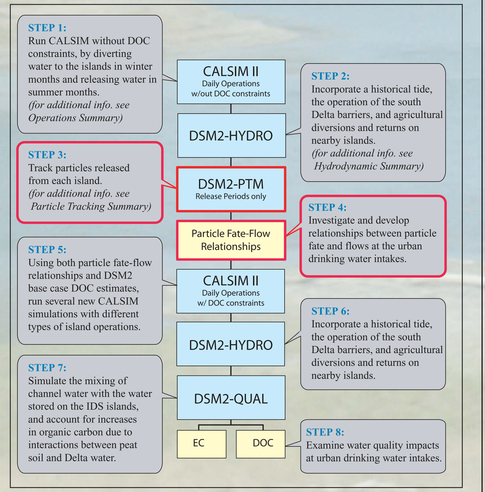


Figure 2: ISI-IDS modeling process. Particle fate flow based relationships were developed in step 3 and step 4 using DSM2-PTM.

Developing Particle Fate - Flow Relationships (Step 4 from Figure 2)

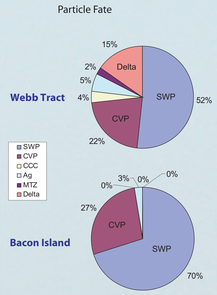
STEP 4.1 Calculate 30-Day Particle Fate for Every Release Period Indepedently for Webb Tract and Bacon Island

Example: July 1975

Delta Hydrology

1975 WATER YEAR CLASSIFICATION:	Wet
HYDRODYNAMICS (Monthly Averages)	
Sacramento River Flow :	17,828 cfs
San Joaquin River Flow:	2,504 cfs
Total Inflow:	20,602 cfs
State Water Project Exports:	6,925 cfs
Central Valley Project Exports:	4,600 cfs
Total Exports:	11,525 cfs
PERMANENT BARRIER STATUS	
Grant Line Canal	Operating
Middle River	Operating
Old River at Tracy	Operating
Head of Old River at San Joaquin R.	Not Installed

Note: Operation of the barriers will increase the flow towards the SWP and CVP near the project islands when the two project pumping facilities are operating.



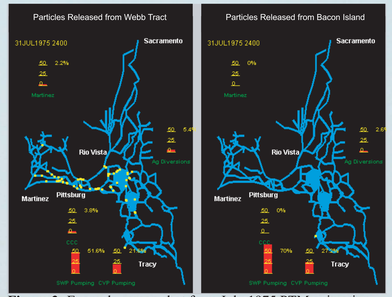


Figure 3: Example screen shot from July 1975 PTM animation.

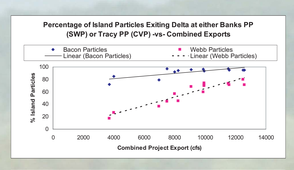
STEP 4.2
Associate Particle Fate with Various Flow Parameters and Indentify Best Particle Fate - Flow Relationship

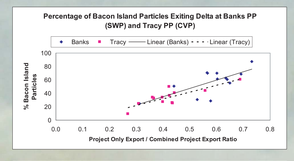
Since the particle fate - flow relationship needed to be easily integrated into CALSIM, flow was represented by parameters that CALSIM could quickly calculate. The following six flow parameters were examined:

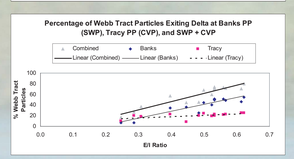
- Combined Exports *(Flows)*
- Combined SWP & CVP Export / Total Delta Inflow Ratio
- SWP Export / Total Delta Inflow Ratio
- CVP Export / Total Delta Inflow Ratio
- SWP Export / Combined SWP & CVP Export Ratio
- CVP Export / Combined SWP & CVP Export Ratio

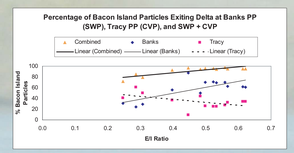
The above flow parameters were compared with particles that exited the Delta at the following three locations:

- Either SWP or CVP (i.e. Combined)
- SWP Only
- CVP Only





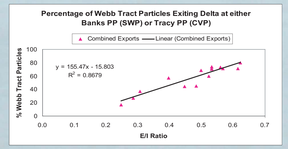


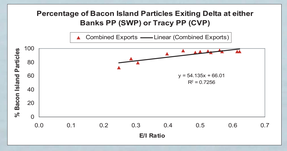


Particle fate from Webb Tract and Bacon Island were significantly different, thus different relationships were developed for the two islands.

STEP 4.3
Hone in on Methodology:
Estimate Total Number of Particles Reaching SWP or CVP based on E/I Ratio

The E/I ratio turned out to be the best flow parameter for estimating the number of particles reaching either export facility for both islands.

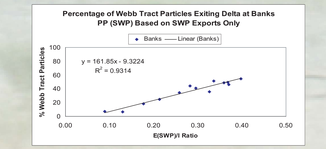




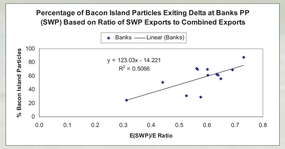
STEP 4.4
Estimate Number of Particles Reaching Just the SWP

Due to differences in the hydrodynamics around each island, different flow parameters were used to estimate the number of particles reaching the SWP for the two islands.

Webb Tract Particles
SWP based on SWP Export / Delta Inflow Ratio



Bacon Island Particles
Estimate Number of Particles Reaching SWP based on SWP Export / Combined Export Ratio



STEP 4.5
Calculate Number of Particles Reaching CVP as the Difference of the SWP & CVP Combined and SWP Only

Once a relationship estimating the total number of particles reaching the combined exports and a separate relationship estimating the number of particles reaching just the SWP are established, the number of particles reaching the CVP is calculated as the difference between the two.

Summary

By using particle fate - flow relationships developed by PTM, CALSIM was able to estimate the amount of the organic carbon released from the IDS islands that would reach the SWP and CVP intakes. CALSIM then used these relationships to limit project island releases in order to meet DOC water quality standards at the SWP and CVP intakes. Although the best approximations of particle fate based on various flow parameters were used, the CALSIM operations used to develop these PTM relationships only represented one very specific type of IDS operation. Different relationships were used to represent the particle fate from each of the islands (Webb Tract and Bacon Island), since the two islands are subject to different hydrodynamics based on their locations within the Delta. This observation underscores the imporatance for developing relationships that accurately characterize the local hydrodynammics associated with the final operations used in CALSIM.

Future Directions

These PTM particle fate-flow relationships were calculated based on a limited number of joint CALSIM-DSM2 simulations. These simulations were limited to project island release periods based on a very specific type of operation for the islands. However, these relationships were then applied within CALSIM for several different types of operations. Future CALSIM-DSM2 simulations can be improved by addressing the following:

- Run PTM for different types of island operations (i.e. circulation or with DOC constraints) and develop operation specific relationships to be used in CALSIM;
- Extend DSM2 to run over the course of the entire 73-year CALSIM simulation period;
- Run PTM in non-release periods;
- Increase the number of particles released for each island;
- Use DSM2-QUAL to conduct a volumetric fingerprinting study and develop volumetric based flow relationships instead of using particle fate based relationships; and
- Modify the random seed used within PTM to increase the number of *realizations* (i.e. runs) relative to the same CALSIM operations.

Acknowledgments

Thanks to Dan Easton for developing the daily CALSIM II model, designing the In-Delta Storage operation rules, and integrating the PTM particle fate-flow relationships into CALSIM, Pal Sandhu, Ganesh Pandey, Amy Bindra, and Rob DuVall for answering my questions about the project islands, Bob Suits and Jim Wilde for providing me with fresh eyes to look over the DSM2 results, Mary Serrato with help printing this poster, and finally Aaron Miller for being the on-call PTM guru.

Additional Info?

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Web Info:

- ISI In-Delta Storage Public Releases:
  http://calfed.water.ca.gov/DeltaImprovements/InDeltaStorage.html
- DSM2:
  http://modeling.water.ca.gov